the north by an Alberta, or farther east by a Hudson Bay anticyclone. The pressure-wave crest usually succeeded in crossing the continent by this system of relays. The direct result of this succession of high and low pressure areas was a frequent alternation in temperature over northern and central districts.

Cyclones.	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total
July, 1922	3.0	1.0	.....	.....	1.0	.....	2.0	.....	2.0	9.0
Average number 1892–1912, inclusive	4.8	0.7	0.3	0.5	0.9	0.2	0.1	0.1	1.0	8.6

Anticyclones.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain region.	Hudson Bay.	Total.
July, 1922	3.0	.....	4.0	2.0	3.0	12.0
Average number 1892–1912, inclusive	1.3	0.3	3.0	1.2	0.8	6.6

FREE-AIR CONDITIONS.

By L. T. SAMUELS, Meteorologist.

Mean free-air temperatures for the month (Table 1) showed a general tendency, with increase in elevation, to approach average conditions. At the surface and lower levels, however, all the departures were negative, and closely conformed in amount with those shown in Climatological Chart III. It will be noted that at Drexel and Royal Center, the regions having the largest departures, these were all negative from the surface to the highest level, while at the other four stations the sign was reversed and positive departures were found in the higher levels. In general, where the negative departures at the surface were smallest the positive departures were found nearer the surface accordingly.

The mean relative humidities were in general inversely proportional to the temperatures as regards departures from the average, a condition to be expected. A prolonged dry spell occurred in the upper levels at Groesbeck from the 9th to the 12th, inclusive, when a rather strong low-pressure area central to the north of Groesbeck caused steady and deep southwesterly winds with resulting low relative humidity. Values from 14 to 20 per cent were reported from the 2,000-meter to 3,000-meter levels during this entire period, whereas the average values for these levels are 52 and 54 per cent, respectively.

Vapor pressure departures conformed in general to the temperature departures with the greatest negative values occurring at Drexel, where it will be noted negative temperature departures were largest.

In Table 2 are given the resultant winds for the month, and it will be noted that these correspond quite closely to the average values. At Drexel, where the largest negative temperature departures occurred, will also be found a much smaller southerly component in the resultant directions than normally. Only a few observations showed wind velocities exceeding 30 meters per second, and these are given in the following table:

Stations.	Date.	Direction.	Velocity.	Altitude.
			m. p. s.	*m.*
Burlington, Vt.	22	WNW	30	6,800
Drexel, Nebr.	13	WNW	30	10,900
Ellendale, N. Dak.	7	NW	30	9,300
Do.	12	NW	34	9,100
Do.	29	WSW	40	9,700
Ellington Field, Tex.	21	SW	44	6,900
Royal Center, Ind.	13	SW	30	10,300
Do.	28	NW	30	6,000
Scott Field, Ill.	23	WNW	30	2,700

All of these were pilot-balloon observations. The kite flight at Royal Center on the morning of the 7th indicated high winds aloft, but the kites were beaten down at 2,000 meters, where the velocity was 29 meters per second. Southwest storm warnings were displayed on the Lower Lakes at 10 a. m. that morning, and because of the quick movement of the storm the warnings were ordered down the following evening.

During the late afternoon and night of the 13th an unusually severe electrical storm occurred at Washington, D. C., the rainfall totaling 3.37 inches, of which 2.79 inches fell within one hour. Examination of the free-air observations in connection with this storm reveals the interesting and significant fact that differently directed air currents prevailed over this section of the country at and previous to the time of the storm. The surface weather map showed this region to be under the influence of a low-pressure trough, lying between two adjacent high-pressure areas, a condition suitable for over and under running currents of air.

Pilot-balloon observations on the afternoon of the 13th at Bolling Field and Washington, D. C., showed northerly winds at the surface, changing through the west to southerly at about 1,500 meters above. Stations to the south of those named above, however, viz, Camp Bragg, N. C.; Langley Field, Va.; and Lee Hall, Va., had southerly winds extending from the surface to the upper levels. Dahlgren, Va., situated between Washington, D. C., and Langley Field, Va., reported northerly winds from the surface to 1,500 meters—the highest level reached. The movement of both the lower and upper clouds at this station, however, was from the south or southwest. Thus it is evident that a southerly current was overrunning a northerly one, the former extending obliquely from the surface at some place south of Dahlgren and north of Langley Field. The 3 p. m. pilot-balloon observation at Washington, D. C., showed this southerly current to be about 1,500 meters above the surface. At Aberdeen, Md., to the north of Washington, this current was not observed, although the balloon was followed to an altitude of 3,000 meters. Furthermore, the Ci.-St. clouds at this observation were reported as moving from the NW.

This condition, i. e., a cool northerly current underrunning one of higher temperature, and the latter probably being very humid, undoubtedly contributed largely toward the production of excessive condensation. It is very probable that in view of the apparent steepness of the slope of this southerly current, the opposite northerly one cut and overran the one from the south, thereby producing favorable conditions for strong convection in these higher levels and terminating in a thunderstorm. Such an unstable condition would be accelerated because of the latent heat liberated by the condensation taking place in the moist layer of air from the south.

On the morning of the 12th the weather map showed the surface isobars to be widely separated in the eastern section of the country and conditions were favorable for high pilot-balloon soundings. The balloon at Washington, D. C., on the morning of this date was observed for 114 minutes and reached an altitude of 20,000 meters. The record appears trustworthy and has been accepted as substantially correct. The wind direction was southerly from the surface to 10,000 meters, above which it was easterly to the highest level observed. The velocity of the southerly wind averaged only 3 or 4 meters per second, but as soon as the upper easterly was encountered the wind speed increased accordingly to about 10 meters per second, falling off again to nearly calm at 14,000 meters and increasing again to 16 meters per second at 19,000 meters. This upper easterly wind was also reached on the same morning at Aberdeen, Md.

On the mornings of the 28th and 29th altitudes of 28,000 and 17,000 meters, respectively, were reached at Broken Arrow, Okla. Both were made with a single theodolite. There was a nearly calm condition of the atmosphere between 6 kilometers and 12 kilometers on the 28th and between 3 kilometers and 14 kilometers on the 29th. On the 28th the velocity increased gradually above 12 kilometers, but from 23 kilometers the record is very likely in error and the balloon probably became leaky, causing an apparent sharp increase in velocity to the highest level. The wind direction above 12 kilometers was northerly. A double-theodolite observation would have been very interesting in connection with such a long run, so that more credence might be placed in the respective altitudes, and therefore another observation was begun with two theodolites, but this was ended when the balloon burst at 14 kilometers. To this height the ascensional rate of the balloon was found to correspond beautifully with the assumed rate in the single-theodolite observation. On the 29th the direction above 14 kilometers was northerly.

Easterly movement of the atmosphere above 10,000 meters was observed as follows:

Station.	Dates.
Aberdeen, Md	12, 13.
Broken Arrow, Okla	15, 24, 25, 28, 29.
Due West, S. C	11, 25.
Ellendale, N. Dak	11.
Groesbeck, Tex	5, 10, 17, 20, 24, 25, 27, 30, 31.
Key West, Fla	26.
Rockwell Field, Calif	12.
San Francisco, Calif	10.
Washington, D. C	12.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during July, 1922.*

TEMPERATURE (°C.).

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.)		Drexel, Nebr. (396m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)	
	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.
Surface	25.9	−1.3	21.9	−3.0	27.0	−0.3	20.2	−0.9	26.6	−0.2	24.2	−1.5
250	25.8	−1.3	.....	.....	26.7	−0.3	.....	.....	25.7	−0.2	23.9	−1.6
500	24.6	−0.6	21.0	−3.3	24.9	+0.3	20.1	−0.7	23.9	−0.1	20.7	−2.3
750	23.4	−0.2	19.7	−3.3	23.2	+0.5	19.2	−0.3	23.0	+0.2	18.8	−2.2
1,000	22.4	+0.3	18.6	−3.0	21.4	+0.5	17.8	−0.5	21.8	+0.2	17.2	−2.1
1,250	21.0	+0.5	17.4	−2.8	19.7	+0.4	16.6	−0.6	20.7	+0.4	15.7	−1.9
1,500	19.4	+0.5	16.3	−2.4	18.1	+0.4	15.2	−0.9	19.4	+0.5	14.1	−1.9
2,000	16.7	+1.0	13.9	−1.7	14.5	+0.1	12.5	−1.0	17.1	+0.9	11.5	−1.7
2,500	14.0	+1.5	10.9	−1.4	10.9	−0.2	9.8	−0.8	14.4	+1.1	9.1	−1.5
3,000	10.7	+1.4	8.1	−0.8	7.6	−0.4	7.4	−0.2	11.5	+1.1	6.3	−1.4
3,500	8.1	+1.6	5.0	−0.4	4.4	−0.4	5.1	+0.6	8.5	+1.2	3.6	−1.1
4,000	4.7	+1.3	1.9	−0.3	1.4	−0.4	3.0	+0.9	4.9	+0.9	0.8	−1.4
4,500	.....	.....	−1.7	−0.7	−1.8	−0.4	1.4	+1.3	.....	.....	.....	.....
5,000	.....	.....	.....	.....	−5.0	−0.4	.....	.....	.....	.....	.....	.....

RELATIVE HUMIDITY (%).

Surface	75	+6	71	+6	71	+1	70	0	75	−1	63	+3
250	74	+5	.....	.....	71	+1	.....	.....	76	0	64	+4
500	66	0	70	+6	70	−1	68	−1	76	0	69	+7
750	61	−4	66	+5	71	−2	64	+1	70	−1	70	+6
1,000	59	−6	64	+4	74	−1	64	+3	67	0	70	+5
1,250	59	−6	62	+3	75	−1	63	+4	62	−3	70	+5
1,500	59	−5	61	+3	74	−1	64	+8	59	−4	70	+5
2,000	54	−7	58	+2	76	+1	63	+10	52	−9	65	+4
2,500	49	−9	53	−1	78	+3	62	+11	53	−6	53	−1
3,000	47	−8	47	−6	76	+2	61	+11	54	−3	52	+2
3,500	35	−15	48	−5	71	+2	62	+10	54	−2	52	+5
4,000	33	−15	47	−4	63	+2	64	+11	67	+7	51	+10
4,500	.....	.....	65	+12	53	+2	69	+12	.....	.....	.....	.....
5,000	.....	.....	.....	.....	51	+2	.....	.....	.....	.....	.....	.....

VAPOR PRESSURE (*mb.*).

Surface	24.96	+0.44	18.64	−1.47	25.08	+0.27	16.49	−0.85	25.53	−0.94	18.62	−0.97
250	24.63	+0.39	.....	.....	24.71	+0.33	.....	.....	24.66	−0.68	18.42	−0.93
500	20.59	−0.47	17.53	−1.59	21.90	+0.29	15.99	−0.77	22.24	−0.44	16.46	−0.84
750	17.46	−1.26	15.32	−1.65	19.99	+0.07	14.21	−0.11	19.16	−0.46	14.84	−0.73
1,000	15.76	−1.21	13.90	−1.49	18.55	+0.11	12.94	+0.13	16.81	−0.40	13.47	−0.70
1,250	14.31	−1.01	12.51	−1.43	17.11	+0.18	11.68	+0.23	14.75	−0.61	12.18	−0.57
1,500	13.07	−0.59	11.33	−1.18	15.16	+0.17	10.80	+0.72	12.99	−0.80	10.94	−0.46
2,000	10.14	−0.58	9.23	−0.69	12.71	+0.34	9.13	+0.95	10.15	−1.17	8.36	−0.24
2,500	7.66	−0.65	7.13	−0.71	10.37	+0.40	7.78	+1.06	8.54	−0.65	5.47	−0.63
3,000	5.77	−0.50	5.13	−0.95	8.29	+0.27	6.65	+1.15	7.29	−0.25	4.38	−0.21
3,500	3.40	−1.21	4.30	−0.50	6.11	+0.27	6.04	+1.30	6.09	−0.07	3.97	+0.39
4,000	2.19	−1.17	3.37	−0.33	4.35	+0.27	5.44	+1.51	5.97	+0.72	3.63	+1.02
4,500	.....	.....	3.23	+0.19	3.17	+0.27	5.38	+1.59	.....	.....	.....	.....
5,000	.....	.....	.....	.....	2.46	+0.27	.....	.....	.....	.....	.....	.....

TABLE 2.—*Free-air resultant winds (m. p. s.) during July, 1922.*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.)				Drexel, Nebr. (396m.)				Due West, S. C. (217m.)			
	Mean.		Average.		Mean.		Average.		Mean.		Average.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S	3.6	S. 3° W.	3.3	S. 2° E.	1.7	S. 1° W.	2.2	S. 62° W.	2.7	S. 62° W.	2.4
250	S	3.6	S. 4° W.	3.4	.....	.....	.....	.....	S. 62° W.	2.9	S. 62° W.	2.5
500	S. 5° W.	4.1	S. 13° W.	4.4	S.	2.5	S. 4° W.	3.0	S. 62° W.	4.1	S. 65° W.	3.1
750	S. 14° W.	4.3	S. 22° W.	4.8	S. 22° W.	3.3	S. 18° W.	4.1	S. 69° W.	4.3	S. 78° W.	3.4
1,000	S. 24° W.	4.2	S. 29° W.	4.7	S. 42° W.	3.5	S. 27° W.	4.5	S. 74° W.	4.5	S. 80° W.	3.9
1,250	S. 33° W.	3.9	S. 33° W.	4.6	S. 49° W.	4.5	S. 37° W.	4.6	S. 77° W.	4.6	S. 82° W.	3.7
1,500	S. 45° W.	4.5	S. 37° W.	4.7	S. 62° W.	4.5	S. 43° W.	4.5	S. 81° W.	5.5	S. 89° W.	4.3
2,000	S. 53° W.	4.3	S. 35° W.	4.0	S. 86° W.	5.6	S. 57° W.	5.0	S. 85° W.	6.3	S. 87° W.	5.2
2,500	S. 57° W.	4.9	S. 38° W.	4.3	N. 84° W.	7.2	S. 71° W.	5.8	S. 85° W.	6.3	S. 85° W.	5.8
3,000	S. 65° W.	5.8	S. 47° W.	5.5	N. 80° W.	9.4	S. 72° W.	6.7	S. 83° W.	6.8	S. 81° W.	7.9
3,500	S. 78° W.	6.8	S. 57° W.	5.0	N. 81° W.	12.3	S. 74° W.	7.6	S. 83° W.	6.5	S. 85° W.	7.3
4,000	S. 62° W.	10.0	S. 31° W.	7.8	N. 79° W.	11.8	S. 73° W.	7.2	N. 89° W.	7.1	.....	.....
4,500	S. 68° W.	17.3	S. 21° W.	8.8	N. 86° W.	11.9	S. 62° W.	8.0	W.	8.8	.....	.....
5,000	.....	.....	.....	.....	S. 45° W.	16.2	S. 63° W.	9.4	W.	7.6	.....	.....

Altitude, m. s. l. (m.)	Ellendale, N. Dak. (444m.)				Groesbeck, Tex. (141m.)				Royal Center, Ind. (225m.)			
	Mean.		Average.		Mean.		Average.		Mean.		Average.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	N. 68° W.	1.5	S. 89° W.	0.2	S. 23° W.	3.9	S. 19° W.	3.4	S. 55° W.	2.9	S. 76° W.	1.6
250	.....	.....	.....	.....	S. 29° W.	5.3	S. 23° W.	4.2	S. 53° W.	3.4	S. 77° W.	1.8
500	N. 80° W.	1.3	S. 34° W.	0.4	S. 41° W.	7.7	S. 33° W.	6.1	S. 55° W.	6.5	S. 73° W.	3.0
750	S. 71° W.	2.1	S. 27° W.	1.1	S. 42° W.	7.7	S. 35° W.	6.2	S. 53° W.	8.5	S. 71° W.	4.1
1,000	S. 75° W.	2.5	S. 49° W.	1.7	S. 43° W.	7.4	S. 36° W.	5.8	S. 62° W.	8.5	S. 77° W.	4.6
1,250	S. 85° W.	2.9	S. 63° W.	2.2	S. 45° W.	7.1	S. 37° W.	5.5	S. 67° W.	9.4	S. 81° W.	5.4
1,500	S. 86° W.	3.7	S. 71° W.	3.1	S. 47° W.	6.0	S. 35° W.	5.4	S. 71° W.	10.2	S. 86° W.	5.7
2,000	N. 70° W.	5.9	S. 85° W.	4.6	S. 51° W.	4.1	S. 34° W.	4.3	S. 73° W.	10.8	S. 86° W.	7.2
2,500	N. 82° W.	7.7	N. 85° W.	6.6	S. 53° W.	3.6	S. 33° W.	3.7	S. 75° W.	14.5	S. 88° W.	9.9
3,000	N. 88° W.	9.8	N. 86° W.	8.5	S. 49° W.	3.3	S. 24° W.	3.6	S. 84° W.	15.4	S. 84° W.	12.4
3,500	N. 87° W.	10.8	N. 80° W.	11.0	S. 18° W.	2.7	S. 2° E.	2.5	N. 89° W.	14.3	S. 80° W.	12.4
4,000	N. 83° W.	10.6	N. 75° W.	10.8	S. 24° W.	5.7	S. 10° E.	0.9	N. 45° W.	16.5	N. 70° W.	8.0
4,500	N. 81° W.	12.3	N. 70° W.	12.1	.....	.....	.....	.....	N. 45° W.	16.9	N. 47° W.	7.8
5,000	W.	15.8	N. 75° W.	14.9	.....	.....	.....	.....	.....	.....	.....	.....